

MULTIPLE FREQUENCY BAND ANTENNA
AND
SIGNAL RECEIVING SYSTEM USING SUCH ANTENNA

5 **[0001]** This invention relates to a multiple frequency band antenna capable of receiving radio waves in a plurality of frequency bands, and, more particularly, to such an antenna having a directivity which is variable in at least one frequency band.

BACKGROUND OF THE INVENTION

10 **[0002]** A variable directivity antenna is known, which has its directivity variable to a direction from which a desired radio wave comes. An example of such variable directivity antennas is a dipole antenna with an asymmetrically loaded feed point disclosed in Page 43 of a book "Antenna Engineering Handbook", First Edition, Eleventh Print, published on January 25, 2001 from
15 The Institute of Electronics, Information and Communication Engineers of Japan.

[0003] According to the technique disclosed in this book, a location to be basically fed of a 1.5 wavelength or 2 wavelength multiple-feed point dipole antenna, which is to be fed at a plurality of locations and, therefore, tends to
20 need a relatively complicated feeding system, is loaded with an impedance, and counterelectromotive force is used for controlling current distribution on the dipole antenna. This handbook states that by electrically controlling the load impedance, the dipole antenna can be a variable directivity antenna.

[0004] The dipole antenna according to the handbook can receive radio
25 waves only in a single frequency band, but it cannot be used to receive radio waves in a plurality of frequency bands. Furthermore, electrical control of the load impedance is troublesome.

[0005] An object of the present invention is to provide a multiple frequency band antenna which has its directivity easily varied at least in one frequency
30 band, and which is capable of receiving radio waves in a plurality of frequency

bands.

SUMMARY OF THE INVENTION

[0006] A multiple frequency band antenna according to an embodiment of the present invention has a dipole antenna, which is arranged on a straight line and may include two straight dipole antenna elements. At least two extension elements extend outward from opposite outer ends of the dipole antenna along the straight line. At least one extension element is disposed at one outer end of the dipole antenna, and at least one extension element is disposed at the other outer end of the dipole antenna. Two or more extension elements may be disposed at each of the one and other outer ends of the dipole antenna. The length of the dipole antenna is so determined as to make the antenna capable of receiving radio waves in a first frequency band, and the sum of the length of the dipole antenna and the extension elements at the respective two outer ends of the dipole antenna is so determined as to make the antenna capable of receiving radio waves in a second frequency band, which is lower than the first frequency band. First and second switch devices are disposed between the at least two extension elements and the outer ends of the dipole antenna, respectively. Control means controls the first and second switch devices to selectively provide a first state in which the first and second switch devices are opened, a second state in which the first switch device is closed and the second switch device is opened, and a third state in which the first switch device is opened and the second switch device is closed, when the antenna is to receive a radio wave in the first frequency band.

[0007] A reactance element may be connected in parallel with each of the first and second switch devices. The values of the reactance elements are so selected that the dipole antenna is substantially disconnected from the extension elements in the first frequency band, and that the dipole antenna is substantially connected to the respective extension elements in the second frequency band. Furthermore, the values of the reactance elements, when the sum of the dipole antenna elements and the extension elements is shorter than

the length required for receiving radio waves in the second frequency band, may be determined such that the reactance elements can provide loading effect that can make it possible to receive well radio waves in the second frequency band. The control means causes the first and second switch devices to be
5 opened when a radio wave in the second frequency band is received.

[0008] The dipole antenna may be formed of two straight dipole antenna elements. Each of the two straight dipole antenna elements may be formed of two parallel, spaced-apart conductors, which are coupled to each other in terms of high frequency. They may be coupled with each other by a capacitor, for
10 example. Each of the first and second switch devices includes a PIN diode connected between the outer end of one of the two conductors of the associated dipole antenna element and the extension element disposed outward of the outer end of that conductor, and a DC current path connected between the outer end of the other conductor and the extension element outward of that
15 outer end.

[0009] According to another embodiment of the present invention, a multiple frequency band antenna includes first and second dipole antennas for receiving radio waves in a first frequency band. The first and second dipole antennas are disposed in parallel with each other and spaced by a distance
20 equal to or shorter than a quarter ($1/4$) of a wavelength in the first frequency band. At least one first extension elements extend outward from each of the opposite outer ends of the first dipole antenna along a first straight line. At least one second extension elements extend outward from each of the opposite outer ends of the second dipole antenna along a second straight line. The
25 sum of the length of the first dipole antenna and the lengths of the first extension elements and the sum of the length of the second dipole antenna and the lengths of the second extension elements are so determined that the multiple frequency band antenna can receive radio waves in a second frequency band which is lower than the first frequency band. First and second
30 switch devices are connected between the two outer ends of the first dipole

antenna and the respective ones of the first extension elements. Third and fourth switch devices are connected between the two outer ends of the second dipole antenna and the respective ones of the second extension elements. The third and fourth switch devices are disposed at locations corresponding to the first and second switch devices, respectively. When a radio wave in the first frequency band is received, control means controls the first through fourth switch devices to selectively place them in a first state in which the first through fourth switch devices are opened, a second state in which the first and third switch devices are closed and the second and fourth switch devices are opened, and a third state in which the first and third switch devices are opened and the second and fourth switch devices are closed.

[0010] Combining means is connected to the first and second dipole antennas. Phase shifting means are connected between respective ones of the first and second dipole antennas and the combining means. The phase shifting means are arranged to be switchable between a first signal coupling state and a second signal coupling state. In the first signal coupling state, the phase shifting means cause a signal from a first direction substantially perpendicular to the first and second dipole antennas as received at the first and second dipole antennas to be coupled to the combining means substantially in phase with each other, and cause a signal from a second direction opposite to the first direction as received at the first and second dipole antennas to be coupled to the combining means substantially 180° out of phase with each other. In the second signal coupling state, the phase shifting means cause a signal from the first direction as received at the first and second dipole antennas to be coupled to the combining means substantially 180° out of phase with each other, and cause a signal from the second direction as received at the first and second dipole antennas to be coupled to the combining means substantially in phase with each other.

[0011] The phase shifting means include first fixed phase shift means connected between the first dipole antenna and the combining means, switch

means connected in parallel with the first fixed phase shift means, and second fixed phase shift means connected between the second dipole antenna and the combining means. The amount of phase shift provided by the first fixed phase shift means is twice the phase shift provided by the second fixed phase shift means.

[0012] According to still other embodiment of the present invention, a multiple frequency band antenna includes an antenna group including first and second orthogonally disposed antennas. Each of the first and second antennas includes first and second dipole antennas disposed in parallel with each other with a spacing equal to or shorter than a quarter ($1/4$) of a wavelength in a first frequency band. A group of extension elements are also provided. The extension element group include a first extension elements extending outward from each of the opposite outer ends of the first dipole antenna along a straight line, and a second extension elements extending outward from each of the opposite outer ends of the second dipole antenna along a straight line. The sum in length of the first dipole antenna and the first extension elements and the sum in length of the second dipole antenna and the second extension elements are determined such that the antenna can receive radio waves in a second frequency band, which is lower than the first frequency band. Also, a group of switch devices are used. The switch device group include first and second switch devices connected between the respective outer ends of the first dipole antenna and the associated first extension elements, and third and fourth switch devices connected between the respective outer ends of the second dipole antenna and the associated second extension elements. The third and fourth switch devices are disposed at locations corresponding to the first and second switch devices, respectively.

[0013] First combining means is connected to the first and second dipole antennas. Phase shifting means are connected between the respective ones of the first and second dipole antennas and the combining means. The phase shifting means are arranged to be switchable between a first signal coupling

state and a second signal coupling state. In the first signal coupling state, the phase shifting means cause a signal from a first direction substantially perpendicular to the first and second dipole antennas as received at the first and second dipole antennas to be coupled to the combining means substantially
5 in phase with each other, and cause a signal from a second direction opposite to the first direction as received at the first and second dipole antennas to be coupled to the combining means substantially 180° out of phase with each other. In the second signal coupling state, the phase shifting means cause a signal from the first direction as received at the first and second dipole antennas to be
10 coupled to the combining means substantially 180° out of phase with each other, and cause a signal from the second direction as received at the first and second dipole antennas to be coupled to the combining means substantially in phase with each other.

[0014] First and second level adjusting means adjust the levels of the
15 signals from the first and second antennas, respectively. Outputs from the first and second level adjusting means are combined by second combining means. Control means controls the first through fourth switch devices of the first and second antennas, the phase shifting means of the first and second antennas, and the first and second level adjusting means, in such a manner that
20 a radio wave in the first or second frequency band from a desired direction can be received. Additional phase shifting means may be connected between respective ones of the first and second level adjusting means and the second combining means.

[0015] The control means may be so configured as to control the first
25 through fourth switch devices of the first and second antennas, the phase shifting means of the first and second antennas, and the first and second level adjusting means, in accordance with a control signal produced by demodulating a modulation signal supplied thereto from modulating means through a transmission path. In this case, a signal from the second combining means is
30 coupled to a receiving apparatus through the transmission path. The

modulating means modulates a carrier with a control signal supplied from the receiving apparatus to produce the modulation signal.

[0016] The modulating means may ASK (amplitude-shift-keying) modulate the carrier.

5 **[0017]** The receiving apparatus may include receiving state detecting means, which detects how a desired signal is being received. The receiving apparatus is provided with receiving apparatus control means, which, when the receiving state changes to an unacceptable one, operates to change the control signal to be supplied to the modulating means and supplies the modulating
10 means with the control signal available when the receiving state as detected by the receiving state detecting means.

[0018] A signal from another antenna may be supplied to the antenna group. In such a case, the antenna group is provided with combining means for combining the signal available from another antenna and the signal available
15 from the antenna group. An output signal from the combining means is supplied through the transmission path to the receiving apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] FIGURE 1 shows part of a multiple frequency band antenna according to a first embodiment of the present invention.

20 **[0020]** FIGURE 2 shows the remaining portion of the antenna of FIGURE 1.

[0021] FIGURE 3 shows a control unit of the antenna of FIGURE 1.

[0022] FIGURE 4 shows controlled states of various portions of the antenna of FIGURE 1.

25 **[0023]** FIGURE 5 is a directivity pattern for the UHF band of the antenna of FIGURE 1 with all switch devices opened.

[0024] FIGURES 6A, 6B and 6C are useful in explaining the principle of control provided in the UHF band of the antenna of FIGURE 1.

[0025] FIGURES 7A, 7B, 7C, 7D and 7E illustrate how the directivity
30 pattern for the UHF band of the antenna of FIGURE 1 can be changed.

[0026] FIGURE 8 illustrates directivity control in the UHF band of the antenna of FIGURE 1.

[0027] FIGURE 9 shows part of a multiple frequency band antenna according to a second embodiment of the present invention.

5 **[0028]** FIGURE 10 shows the remaining portion of the antenna shown in FIGURE 9.

[0029] FIGURE 11 illustrates directivity control in the UHF band of the antenna of FIGURE 9.

10 **[0030]** FIGURE 12 is a block diagram of a signal receiving system which employs a modification of the multiple frequency band antenna shown in FIGURE 9.

[0031] FIGURE 13 is a block diagram of the modified multiple frequency band antenna used in the signal receiving system shown in FIGURE 12.

EMBODIMENTS

15 **[0032]** A multiple frequency band antenna according to a first embodiment of the present invention is arranged to receive radio waves in a first frequency band or UHF band, for example, ranging from 470 MHz to 890 MHz, and in a second frequency band or VHF band, for example, ranging from 54 MHz to 216 MHz. In addition, the multiple frequency band antenna has its directivity
20 variable in the UHF and VHF bands, in a plurality of steps spaced by a predetermined amount, in sixteen (16) steps spaced by an angle of 22.5°, for example.

[0033] As shown in FIGURE 1, the multiple frequency band antenna according to the first embodiment has an antenna group including a first
25 antenna 2a and a second antenna 2b.

[0034] The first antenna 2a may be formed on a printed circuit board (not shown), for example, and includes first and second dipole antennas 4a and 6a.

[0035] The first dipole antenna 4a includes dipole antenna elements 8a and 10a, which are arranged on a single straight line and have the same length.
30 The length of the dipole antenna elements 8a and 10a is about a quarter (1/4)

of a given wavelength λ in the UHF band, for example. The dipole antenna element 8a includes two conductors 12a and 14a arranged in parallel with each other. A plurality of capacitors 16a are connected between the two conductors 12a and 14a at predetermined intervals along the length of the conductors.

5 The capacitors 16a place the two conductors 12a and 14a at the same potential in terms of high frequency. Similarly, the dipole antenna element 10a includes two conductors 18a and 20a disposed in parallel with each other and connected to each other by a plurality of capacitors 22a at predetermined intervals along the conductors so that the conductors 18a and 20a are placed at the same

10 potential in terms of high frequency. The entire length of the first dipole antenna 4a, which is substantially equal to the sum of the lengths of the dipole antenna elements 8a and 10a, is about a half ($1/2$) of the wavelength λ .

[0036] Outward of the outer end of the dipole antenna element 8a, an extension element 24a is disposed along the same straight line on which the dipole antenna elements 8a and 10a are disposed. Similarly, an extension element 26a is disposed outward of the outer end of the dipole antenna element 10a along the same straight line on which the dipole antenna elements 8a and 10a are disposed. The sum of the lengths of the dipole antenna element 8a and the extension element 24a is shorter than about a quarter ($1/4$) of a given

15 wavelength λ_1 in the VHF band, and, similarly, the sum of the lengths of the dipole antenna element 10a and the extension element 26a is shorter than about a quarter ($1/4$) of the given wavelength λ_1 .

[0037] A switch device, e.g. a PIN diode 28a, is connected between the conductor 14a of the dipole antenna element 8a and the extension element 24a.

25 In the example shown in FIGURE 1, the anode of the PIN diode 28a is connected to the extension element 24a and the cathode is connected to the conductor 14a. A DC path, e.g. a current limiting resistor 29a, is connected between the conductor 12a of the dipole antenna element 8a and the extension element 24a. Therefore, by applying a DC voltage between the conductors

30 12a and 14a, with the conductor 12a being positive and with the conductor 14a

being negative, the PIN diode 28a is rendered conductive, so that the extension element 24a is electrically connected to the conductors 12a and 14a. Since the conductors 12a and 14a are connected together in terms of high frequency, the extension element 24a is connected to the parallel combination of the conductors 12a and 14a in terms of high frequency. Without the voltage stated above, the PIN diode 28a is nonconductive, and, therefore, the extension element 24a and the parallel combination of the conductors 12a and 14a are electrically disconnected from each other.

[0038] A series combination of an inductance element 30a and a DC blocking capacitor 32a is connected in parallel with the PIN diode 28a. The value of the inductance element 30a is determined such that at frequencies in the UHF band, the extension element 24a is substantially disconnected from the parallel conductors 12a and 14a, and at frequencies in the VHF band, the extension element 24a is substantially connected to the parallel conductors 12a and 14a, and that the sum electrical length of the dipole antenna element 8a and the extension element 24a can be equal to about a quarter ($1/4$) of the given wavelength λ_1 in the VHF band. The inductance element 30a acts as a switch device, too. Thus, at frequencies in the VHF band, the extension element 24a is substantially connected to the parallel conductors 12a and 14a even when the PIN diode 28a is nonconductive.

[0039] Similarly, a PIN diode 34a, a current limiting resistor 36a, an inductance element 38a, and a DC blocking capacitor 40a are connected between the conductors 18a and 20a of the dipole antenna element 10a and the extension element 26a in the same manner as described with respect to the dipole antenna element 8a. The length of the extension element 26a is determined in the same manner as the extension element 24a, and the value of the inductance element 38a is determined in the same manner as the inductance element 30a.

[0040] The second dipole antenna 6a is configured in the same manner as the first dipole antenna 4a, and includes dipole antenna elements 42a and 44a.

The dipole antenna element 42a includes parallel conductors 46a and 48a, and the dipole antenna element 44a includes parallel conductors 50a and 52a. The conductors 46a and 48a are connected together by means of plural capacitors 54a in terms of high frequency, and the conductors 50a and 52a are
5 connected together by means of plural capacitors 56a in terms of high frequency. Extension elements 58a and 60a are disposed outward of the outer ends of the dipole antenna elements 42a and 44a, respectively. A PIN diode 62a, a current limiting resistor 64a, an inductance element 66a and a DC blocking capacitor 68a are connected between the dipole antenna element 42a
10 and the extension element 58a, as shown. Similarly, a PIN diode 70a, a current limiting resistor 72a, an inductance element 74a and a DC blocking capacitor 76a are connected between the dipole antenna element 44a and the extension element 60a, as shown. The lengths of the extension elements 58a and 60a are determined in the same manner as the extension elements 24a and
15 26a, and the values of the inductance elements 66a and 74a are determined in the same manner as the inductance elements 30a and 38a.

[0041] The second dipole antenna 6a is disposed in parallel with the first dipole antenna 4a and is spaced from the first dipole antenna 4a by a distance shorter than a quarter ($1/4$) of the given wavelength λ in the UHF band.

[0042] Feed points are provided by the inner ends of the dipole antenna elements 8a and 10a of the first dipole antenna 4a, and the inner ends of the conductors 14a and 20a are connected to a matching device, e.g. a balun 78a. Similarly, feed points are provided by the inner ends of the dipole antenna elements 42a and 44a of the second dipole antenna 6a, and the inner ends of
25 the conductors 46a and 50a are connected to a matching device, e.g. a balun 80a.

[0043] A series combination of high-frequency blocking coils 82a and 84a is connected between the conductors 12a and 48a, and capacitors 86a and 88a are connected between the junction of the coils 82a and 84a and a point of
30 reference potential, as shown. A voltage supply terminal 90a is connected to

the junction of the coils 82a and 84a for application of a positive voltage to render the PIN diodes 28a and 62a conductive. Also, a series combination of high-frequency blocking coils 92a and 94a is connected between the conductors 18a and 52a, and capacitors 96a and 98a are connected between the junction
5 of the coils 92a and 94a and a point of reference potential, as shown. A voltage supply terminal 100a is connected to the junction of the coils 92a and 94a for application of a voltage to render the PIN diodes 34a and 70a conductive. The baluns 78a and 80a have points connected to a point of reference potential, and, therefore, the application of a positive voltage to the
10 voltage supply terminal 96a or 100a causes a current to flow from the balun 78a or 80a to the reference potential point.

[0044] The second antenna 2b has substantially the same structure as the first antenna 2a, and is formed on a different printed circuit board than the first antenna 2a. Components of the second antenna 2b are provided with the
15 same reference numerals as the equivalent components of the first antenna 2a, with the suffix letter "a" replaced by a suffix "b", and their detailed description is not made. The second antenna 2b is disposed substantially orthogonal to the first antenna 2a, with its center coinciding with the center of the first antenna 2a. The second antenna 2b does not contact the first antenna 2a.

[0045] As shown in FIGURE 2, output signals of the baluns 78a and 80a of the first antenna 2a are amplified in amplifiers 102a and 104a, respectively, and applied to a variable phase shifter 106a.
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[0046] Specifically, an output signal of the amplifier 102a is applied to a first phase shift circuit of the variable phase shifter 106a. The first phase shift
25 circuit includes a series combination of a fixed phase shifter 108a and switch devices, e.g. PIN diodes 110a and 112a, which are connected to the respective ends of the fixed phase shifter 108a. Another series circuit of switch devices, e.g. PIN diodes 114a and 116a, is connected in parallel with the series combination of the phase shifter 108a and the PIN diodes 110a and 112a.
30 The fixed phase shifter 108a is provided by a delay line, for example, or, more

specifically, a coaxial cable or a microstrip line of a given length.

[0047] More specifically, the PIN diode 110a has its anode connected to the input of the fixed phase shifter 108a and has its cathode connected to the output of the amplifier 102a. The PIN diode 112a has its anode connected to the output of the fixed phase shifter 108a and has its cathode connected to a combiner 118a. The junction of the PIN diode 110a and the fixed phase shifter 108a is connected through a resistor 120a to a voltage supply terminal 122a. The cathodes of the PIN diodes 110a and 112a are connected to a point of reference potential through high-frequency blocking coils 124a and 126a, respectively. Accordingly, when a positive voltage is applied to the voltage supply terminal 122a, while the PIN diodes 114a and 116a are nonconductive, the PIN diodes 110a and 112a are rendered conductive, and the output of the amplifier 102a is delayed in the fixed phase shifter before being applied to the combiner 118a.

[0048] The anodes of the PIN diodes 114a and 116a are connected to each other. The cathode of the PIN diode 114a is connected to the cathode of the PIN diode 110a, and the cathode of the PIN diode 116a is connected to the cathode of the PIN diode 112a. The junction of the anodes of the PIN diodes 114a and 116a is connected to a voltage supply terminal 130a via a resistor 128a. Accordingly, when a positive DC voltage is applied to the voltage supply terminal 130a, the PIN diodes 114a and 116a are rendered conductive, and, therefore, the output of the amplifier 102a is coupled to the combiner 118a without being modified.

[0049] In the variable phase shifter 106a, the output signal of the amplifier 104a is applied to the combiner 118a via a fixed phase shifter 132a and an attenuator 134a. The fixed phase shifter 132a and the attenuator 134a form a second phase shift circuit. The fixed phase shifter 132a has the same configuration as the phase shifter 108a.

[0050] The amount of delay provided by the fixed phase shifter 108a to the output signal of the amplifier 102a is twice as much as the amount of delay

provided by the fixed phase shifter 132a to the output signal of the amplifier 104a. The amount of delay provided by the fixed phase shifter 132a is so determined as to make the first antenna 2a exhibit a directivity in a particular direction, for example, in the backward direction in the UHF band.

5 **[0051]** Specifically, let it be assumed that the dipole antenna 4a is disposed to face forward, with the dipole antenna 6a facing backward. A radio wave coming toward the front of the first antenna 2a is received by the dipole antennas 4a and 6a, but the signal received by the dipole antenna 6a is delayed from the signal received by the dipole antenna 4a due to the spacing between
10 the dipole antennas 4a and 6a. By further delaying the signal received at the dipole antenna 6a by such an amount as to provide a total amount of about $\lambda/2$, the signal received at the dipole antenna 6a can be made substantially 180° out of phase with the signal received at the dipole antenna 4a. When the signals as received at the dipole antennas 4a and 6a, which are 180° out of phase with
15 each other are combined, the first antenna 2a does not exhibit directivity in the forward direction. A radio wave toward the back of the first antenna 2a from behind the first antenna 2a is also received by the dipole antennas 4a and 6a, but the signal received by the dipole antenna 4a is delayed from the signal as received by the dipole antenna 6a by the amount corresponding to the spacing
20 between the two dipole antennas 4a and 6a. By delaying the signal received by the dipole antenna 6a by an appropriate amount, the phase difference between the signals received by the dipole antennas 4a and 6a can be reduced, so that the two received signals can be substantially in phase with each other, which means that the first antenna 2a exhibits directivity in the backward
25 direction. The amount of delay provided by the fixed phase shifter 132a is determined to realize such control of the delay amounts.

30 **[0052]** From the above description, it is understood that in order to realize backward directivity of the first antenna 2a, the PIN diodes 114a and 116a are rendered conductive, and the PIN diodes 110a and 112a are rendered nonconductive.

[0053] Similarly, for realizing forward directivity of the first antenna 2a, the delaying by the fixed phase shifter 132a is reversed by 180°. For that purpose, the PIN diodes 110a and 112a are rendered conductive, and the PIN diodes 114a and 116a are rendered nonconductive. The output signal of the amplifier 102a is delayed in the fixed phase shifter 108a by an amount twice the amount of delay the fixed phase shifter 132a gives the output signal from the amplifier 104a. The signals resulting from the reception by the dipole antennas 4a and 6a of a radio wave coming toward the front side of the first antenna 2a from the front are substantially in phase with each other, while the signals resulting from the reception by the dipole antennas 4a and 6a of a radio wave coming from behind the first antenna 2a are substantially 180° out of phase with each other. The amplified and delayed versions of the signals from the baluns 78a and 80a are combined in the combiner 118a. This realizes forward directivity of the antenna 2a. As described, the directivity of the first antenna 2a can be switched between the forward and the backward by ON-OFF controlling the PIN diodes 110a, 112a, 114a and 116a.

[0054] Similarly, the signal received by the second antenna 2b is processed in a variable phase shifter 106b so that the second antenna 2b can exhibit selectively the rightward directivity and the leftward directivity. The configuration of the variable phase shifter 106b is the same as the variable phase shifter 106a. Therefore, components of the variable phase shifter 106b equivalent to the ones of the variable phase shifter 106a are provided with the same reference numerals as used for the components of the phase shifter 106a, with a suffix "b" substituted for "a", and no further description is given. It should be noted, however, that baluns 78b and 80b are connected respectively to amplifiers 104b and 102b.

[0055] The variable phase shifter 106a outputs a signal with forward or backward directivity, and the variable phase shifter 106b outputs a signal with rightward or leftward directivity. The directivities of the signals from the variable phase shifters 106a and 106b are selected as desired, and the signals

are applied to level adjusting means, e.g. variable attenuators 136a and 136b, respectively, to thereby adjust their levels as desired, and combined the level adjusted signals with each other, so that the directivity of the antenna can be changed to any desired direction. Each of the variable attenuators 136a and 136b is configured to be able to provide one of three attenuation amounts, namely, 0 dB, 7dB and infinite (∞). By the adjustment of the amounts of attenuation provided by the variable attenuators 136a and 136b, in combination with the adjustment of the directivities of the first and second antennas 2a and 2b through the adjustment of the variable phase shifters 106a and 106b, the directivity of the multiple frequency band antenna can be varied in, for example, sixteen (16) steps by a predetermined angular spacing of 22.5°.

[0056] For that purpose, the variable attenuator 136a includes switch devices, such as PIN diodes 140a and 142a, connected in series between the combiner 118a and another combiner 138. The PIN diode 140a has its cathode connected to the output of the combiner 118a and has its anode connected to the anode of the PIN diode 142a, which has its cathode connected to an input of the combiner 138. The mutually connected anodes of the PIN diodes 140a and 142a are connected through a resistor 144a to a voltage supply terminal 146a. The cathodes of the PIN diodes 140a and 142a are connected through respective high-frequency blocking coils 148a and 150a to a point of reference potential. When a positive voltage is applied to the voltage supply terminal 146a, the PIN diodes 140a and 142a are rendered conductive, so that the signal from the variable phase shifter 106a is coupled to the combiner 138 without being attenuated.

[0057] The variable attenuator 136a includes a fixed attenuator, e.g. a T-type attenuator 154a. The attenuator 154a includes three resistors 152a and provides an amount of attenuation of 7 dB. The input of the attenuator 154a is connected to a switch device. In the illustrated example, a PIN diode 156a is used as this switch device. The PIN diode 156a has its anode connected to the input of the attenuator 154a and has its cathode connected to

the cathode of the PIN diode 140a. The output of the attenuator 154a is connected to a switch device. In the illustrated example, a PIN diode 158a is used as this switch device. The PIN diode 158a has its anode connected to the output of the attenuator 154a, and has its cathode of the PIN diode 158a connected to the cathode of the PIN diode 142a. The junction of the three resistors 152a of the T-type attenuator 154a is connected through a resistor 160a to a voltage supply terminal 162a. Accordingly, when a positive voltage is applied to the voltage supply terminal 162a, the PIN diodes 156a and 158a are rendered conductive, so that the T-type attenuator 154a is connected between the combiners 118a and 138. Thus, the signal from the variable phase shifter 106a is given an amount of attenuation of 7 dB.

[0058] The variable attenuator 136a includes further a matching resistor 164a having an impedance equal to the impedance of the first antenna 2a. The resistor 164a has its one end connected to a reference potential point, and has the other end connected through a DC blocking capacitor 170a to a switch device. In the illustrated example, a PIN diode 166a is used as this switch device. The other end of the resistor 164a is connected to the anode of the PIN diode 166a through the DC blocking capacitor 170a. The cathode of the PIN diode 166a is connected through a resistor 172a to a voltage supply terminal 174a. Accordingly, when a positive voltage is applied to the voltage supply terminal 174a, the PIN diode 166a is rendered conductive, so that the output of the combiner 118a is connected to a reference potential point through the matching resistor 164a and is subjected to attenuation of an infinite magnitude.

[0059] The variable attenuator 136b is configured similarly to the variable attenuator 136a. Components equivalent to the ones of the attenuator 136a are provided with the same reference numerals with the suffix "a" replaced by "b", and no further detailed description about the attenuator 136b is given.

[0060] For varying the directivity as described above, the multiple frequency band antenna has a 16-direction switch 176, as shown in FIGURE 3.

The switch 176 is arranged to selectively provide output signals corresponding to sixteen (16) directions angularly spaced by 22.5° starting from 0° . In the direction of 0° , the directivity is exhibited in the straight forward direction of the antenna. The output signal of the 16-direction switch 176 is applied to an encoder 178, where it is converted into one of sixteen (16) 4-bit coded signals "0000", "0001", ..., "1111", corresponding to the respective ones of the sixteen directions, as shown in FIGURE 4. The coded signal is applied to a control unit 180. The control unit 180 responds to the inputted 4-bit coded signal and supplies appropriate voltages to the respective voltage supply terminals 122a, 130a, 122b, 130b, 146a, 162a, 174a, 146b, 162b and 174b. The output A of the control unit 180 is coupled to the voltage supply terminal 130a in FIGURE 2, the output a is coupled to the terminal 122a, the output B is to the terminal 130b, the output b is to 122b, the output C is to the terminal 146a, the output D is to the terminal 162a, the output E is to the terminal 174a, the output F is to the terminal 146b, the output G is to the terminal 162b, and the output H of the control unit 180 is coupled to the voltage supply terminal 174b. In FIGURE 4, the letters A, a, B, b, C, D, E, F, G and H correspond respectively to the outputs of the control unit 180. In FIGURE 4, a numeral "1" denotes that a positive voltage is applied to the associated voltage supply terminals, and a numeral "0" denotes that no voltage is applied.

[0061] For the directivity of 0° , 22.5° and 45° , the variable attenuator 154a provides attenuation of 0 dB. For the directivity of 67.5° and 90° , the variable attenuator 154a provides an increasing amount of attenuation, namely, 7 dB and infinity. For the directivity of 112.5° and 135° , the attenuator 154a provide a decreasing amount of attenuation of 7 dB and zero (0). For the directivity of 157.5° , 180° , 202.5° and 225° , the amount of attenuation provided by the attenuator 154a remains zero (0). For the directivity of 247.5° and 270° , the attenuator 154a provides an increasing amount of attenuation, namely, 7 dB and infinity. For the directivity of 292.5° and 315° , the attenuator 154a provides a decreasing amount of attenuation, namely, 7 dB and zero (0). For

the directivity of 337.5° , the amount of attenuation provided by the variable attenuator 154a is zero (0).

[0062] For the directivity of 0° , 22.5° and 45° , the variable attenuator 154b provides a decreasing amount of attenuation, namely, from infinity through 7 dB to zero (0). For the directivity of 67.5° , 90° , 112.5° and 135° , the variable attenuator 154b provides a constant amount of attenuation of zero (0). For the directivity of 157.5° and 180° , the variable attenuator 154b provides an increasing amount of attenuation, namely, 7 dB and infinity. For the directivity of 202.5° and 225° , the attenuator 154b provides a decreasing amount of attenuation, namely, 7 dB and zero (0). For the directivity of 247.5° , 270° , 292.5° and 315° , the attenuator 154b provides a constant amount of attenuation of zero (0). For the directivity of 337.5° , the amount of attenuation provided by the variable attenuator 154b is 7 dB. As described, when one of the variable attenuators 154a and 154b is providing an amount of attenuation of 0 dB, the amount of attenuation provided by the other increases or decreases.

[0063] Similar control is provided for either of UHF or VHF band reception. It should be noted that, when a radio wave in the VHF band is received, the extension elements 24a, 24b, 26a, 26b, 58a, 58b, 60a and 60b are connected to the associated dipole antenna elements 8a, 8b, 10a, 10b, 42a, 42b, 44a and 44b, respectively, by means of the inductance elements 30a, 30b, 38a, 38b, 66a, 66b, 74a and 74b, respectively.

[0064] As described above, the directivity of the multiple frequency band antenna according to the present invention can have its directivity varied both in the VHF band and the UHF band. In the UHF band, however, since the spacing between the dipole antennas 4a and 6a of the first antenna 2a, and the spacing between the dipole antennas 4b and 6b of the second antenna 2b are each less than $\lambda/4$, the directivity of the multiple frequency band antenna is more acute than when the spacing is $\lambda/4$. Therefore, when the signals are combined in the manner described above, the directivity pattern exhibits depressions at the angles other than 0° , 90° , 180° and 270° , as shown in

FIGURE 5.

[0065] In order to solve this problem, the extension elements 24a, 26a, 58a and 60a are used. For example, by rendering the PIN diodes 34a and 70a conductive to thereby connect the extension elements 26a and 60a to the dipole antenna elements 10a and 44a, respectively, when the first antenna 2a is set to exhibit the forward directivity represented by an arrow 200 in FIGURE 6A through the adjustment of the variable phase shifter 106a, the dipole antenna elements 10a and 44a behave together as an asymmetrically loaded feed point dipole antenna described previously with respect to prior art, of which the directivity is tilted toward the 90° direction (i.e. the rightward direction along the horizontal axis in FIGURE 6A) as represented by an arrow 202. On the other hand, when the extension elements 24a and 58a are connected respectively to the dipole antenna elements 8a and 42a by rendering the PIN diodes 28a and 62a conductive, the directivity of the resultant antenna tilts toward the 270° direction (i.e. the leftward direction along the horizontal axis in FIGURE 6A) as represented by an arrow 204. Similarly, when the antenna exhibits the backward directivity as represented by a broken-line arrow 206 in FIGURE 6A, by connecting the extension elements 26a and 60a to the dipole antenna elements 10a and 44a, respectively, by rendering the PIN diodes 34a and 70a conductive, the directivity of the resultant antenna tilts toward the 90° direction as indicated by a broken-line arrow 208. By rendering the PIN diodes 28a and 62a conductive to thereby connect the extension elements 24a and 58a to the dipole antenna elements 8a and 42a, respectively, the directivity of the resultant antenna tilts toward the 270° direction as indicated by a broken-line arrow 210.

[0066] Similarly, in the second antenna 2b, with its directivity oriented rightward as indicated by an arrow 212, as shown in FIGURE 6B, through the adjustment of the variable phase shifter 106b, by rendering the PIN diodes 34b and 70b conductive to thereby connect the extension elements 26b and 60b to the dipole antenna elements 10b and 44b, respectively, the directivity of the antenna tilts toward the 180° direction (i.e. the downward direction along the

vertical axis in FIGURE 6B), as indicated by an arrow 214. When the PIN diodes 28b and 62b are rendered conductive to thereby connect the extension elements 24b and 58b to the dipole antenna elements 8b and 42b, respectively, the antenna directivity tilts toward the 0° direction (i.e. the upward direction along the vertical axis in FIGURE 6B), as represented by an arrow 216. Similarly, with the leftward directivity as represented by a broken-line arrow 218, by rendering the PIN diodes 34b and 70b conductive to thereby connect the extension elements 26b and 60b to the dipole antenna elements 8b and 42b, respectively, the antenna directivity tilts toward the 180° direction as represented by a broken-line arrow 220. By rendering the PIN diodes 28b and 62b conductive to connect the extension elements 24b and 58b to the dipole antenna elements 8b and 42b, respectively, the antenna directivity tilts toward the 0° direction as indicated by a broken-line arrow 222.

[0067] Let it be assumed that the directivity is to be changed within a range of from 22.5° to 67.5°. First, as shown in FIGURE 6C, the direction of directivity of the first antenna 2a is tilted rightward from its primary direction, and the direction of directivity of the second antenna 2b is tilted leftward from its primary direction. Then, the outputs of the first and second antennas 2a and 2b are combined in the manner described above, and the directions of the directivity of the first and second antennas 2a and 2b approach toward each other. As a result, as shown in FIGURES 7A through 7E, no remarkable depressions appear in the directivity patterns at any of the shown directions. The same result is obtained at the other directions.

[0068] To realize the above, the control unit 180 applies voltages to the voltage supply terminals 90a, 90b, 100a and 100b, too, in response to signals supplied to it from the encoder 178, as shown in FIGURE 8. In FIGURE 8, letters I, J, K and L represent the voltages to be applied to the voltage supply terminals 90a, 100a, 90b and 100b, respectively. A numeral "1" denotes that a positive voltage is applied, whereas a numeral "0" denotes that no voltage is applied. As is understood from FIGURE 8, for the directivity in the directions

at 22.5°, 45° and 67.5°, the directivity of the first antenna 2a is tilted toward the 90° direction (as represented by the arrow 202 in FIGURE 6A), and the directivity of the second antenna 2b is tilted toward the 0° direction (as represented by the arrow 216 in FIGURE 6B). For the directivity in the directions at 112.5°, 135° and 157.5°, the directivity of the first antenna 2a is tilted toward the 90° direction (as represented by the arrow 208 in FIGURE 6A), and the directivity of the second antenna 2b is tilted toward the 180° direction (as represented by the arrow 214 in FIGURE 6B). For the directivity in the directions at 202.5°, 225° and 247.5°, the directivity of the first antenna 2a is tilted toward the 270° direction (as represented by the arrow 210 in FIGURE 6A), and the directivity of the second antenna 2b is tilted toward the 180° direction (as represented by the arrow 220 in FIGURE 6B). For the directivity in the directions at 292.5°, 315° and 337.5°, the directivity of the first antenna 2a is tilted toward the 270° direction (as represented by the arrow 204 in FIGURE 6A), and the directivity of the second antenna 2b is tilted toward the 0° direction (as represented by the arrow 222 in FIGURE 6B).

[0069] With the above-described arrangement of the multiple frequency band antenna according to the present invention, the extension elements 24a, 24b, 26a, 26b, 58a, 58b, 60a and 60b, which are primarily used to receive radio waves in the VHF band, are taken advantage of in order to vary the directivity of the antenna in the UHF band. Accordingly, no additional components are required for varying the directivity in the UHF band. In addition, the control for varying the antenna directivity can be achieved by slightly modifying the control primarily provided by the control unit 180.

[0070] FIGURES 9, 10 and 11 show a multiple frequency band antenna according to a second embodiment of the present invention. The overall configuration of the multiple frequency band antenna according to the second embodiment is substantially the same as that of the antenna according to the first embodiment, except the following. Accordingly, components and functions equivalent to those of the antenna of the first embodiment are given

the same reference numerals and symbols as used for the first embodiment, and their detailed description is not given. The antenna according to the second embodiment differs from the one according to the first embodiment in the connections of the baluns 78a and 78b. In addition, variable phase shifters 300a and 300b (FIGURE 10) are added.

[0071] As shown in FIGURE 9, the connection of the balun 78a to the dipole antenna elements 8a and 10a is reversed relative to the connection of the balun 80a to the dipole antenna elements 42a and 44a. Similarly, the connection of the balun 78b to the dipole antenna elements 8b and 10b is reversed relative to the connection of the balun 80b to the dipole antenna elements 42b and 44b. Due to this connection, signals developed in the baluns 78a and 80a are 180° out of phase with each other, with the phase difference caused by the distance between the dipole antennas 4a and 6a ignored. Similarly, signals developed in the baluns 78b and 80b are 180° out of phase with each other, with the phase difference caused by the distance between the dipole antennas 4b and 6b ignored. With such connections of the baluns, the voltage (A) applied to the voltage supply terminal 130a and the voltage (a) applied to the voltage supply terminal 122a are reversed from the ones used in the antenna arrangement according to the first embodiment, as shown in FIGURE 11. Also, the voltage (B) applied to the voltage supply terminal 130b and the voltage (b) applied to the voltage supply terminal 122b are reversed from the ones used in the antenna arrangement according to the first embodiment.

[0072] As shown in FIGURE 10, in the multiple frequency band antenna according to the second embodiment, the variable phase shifter 300a is connected between the output of the variable attenuator 136a and the input of the combiner 138. Similarly, the variable phase shifter 300b is connected between the output of the variable attenuator 136b and the input of the combiner 138.

[0073] The variable phase shifters 300a and 300b have the same

configuration as the first phase circuit of the variable phase shifter 106a. Accordingly, when a H-level voltage is applied to a voltage supply terminal 302a, a current flows through a resistor 304a and PIN diodes 306a and 308a, so that the output signal of the variable attenuator 136a is applied as it is to the combiner 138. On the other hand, if a H-level voltage is applied to a voltage supply terminal 310a, a current flows through a resistor 312a, a PIN diode 314a and a high-frequency blocking coil 316a, and also a current flows through the resistor 312a, a phase shifter 318a, a PIN diode 320a and a high-frequency blocking coil 322a, so that the phase of the output signal of the variable attenuator 136a is adjusted in the phase shifter 318a before it is applied to the combiner 138. When a H-level voltage is being applied to the voltage supply terminal 302a, the voltage supply terminal 310a is not supplied with a H-level voltage, and when a H-level voltage is being applied to the voltage supply terminal 310a, the voltage supply terminal 302a is not supplied with a H-level voltage.

[0074] The variable phase shifter 300b has the same configuration as the variable phase shifter 300a, and its components equivalent to those of the variable phase shifter 300a are given the same reference numerals with the suffix "b" and their detailed description is no given.

[0075] In realizing the directivity in a range between 0° and 90° , the antenna 2a uses the phase shifter 132a only, but the antenna 2b uses the phase shifters 132b and 108b. Accordingly, a phase difference is present between the output signal of the variable attenuator 136a corresponding to the signal received by the antenna 2a and the output signal of the variable attenuator 136b corresponding to the signal received by the antenna 2b, which are to be applied to the combiner 138. Such phase difference results in undesirable effects in the directivity pattern. Similar effects are seen when the directivity in a direction between 180° and 270° is to be obtained. When a directivity in the range of from 90° to 180° is to be achieved, both the antennas 2a and 2b utilize the phase shifters 132a and 108a and 132b and 108b,

respectively, and, therefore, no phase difference is exhibited between the signals to be applied to the combiner 138 from the attenuator 136a corresponding to the signal received at the antenna 2a, and from the attenuator 136b corresponding to the signal received at the antenna 2b. When a
5 directivity in the range of from 270° to 360° is to be achieved, both the antennas 2a and 2b utilize the phase shifters 132a and 132b, respectively, and, therefore, no phase difference is exhibited between the signals applied to the combiner 138.

[0076] The amounts of phase to be shifted by the phase shifters 300a and
10 300b are set to cancel the phase difference described above. For the directivity between 0° and 90° , a H-level voltage is applied to the voltage supply terminal 310a to cause the phase shifter 300a to adjust the phase of the signal from the variable attenuator 136a before applying it to the combiner 138, while a H-level voltage is applied to the voltage supply terminal 302b to cause
15 the signal from the variable attenuator 136b corresponding to the signal received at the second antenna 2b to be applied as it is to the combiner 138. For the directivity in a range of from 90° to 180° , a H-level voltage is applied to each of the voltage supply terminals 302a and 302b so that the signals from the variable attenuators 136a and 136b can be applied to the combiner 138 without
20 being modified. For the directivity in a range of from 180° to 270° , a H-level voltage is applied to the voltage supply terminal 310b to cause the phase shifter 300b to phase adjust the signal from the variable attenuator 136b before applying it to the combiner 138, whereas a H-level voltage is applied to the voltage supply terminal 302a so that the signal from the attenuator 136a can be
25 applied as it is to the combiner 138. For the directivity in a range of from 270° to 360° , a H-level voltage is applied to each of the voltage supply terminals 302a and 302b so that the signals from the variable attenuators 136a and 136b can be applied to the combiner 138 without being modified. These H-level voltages are provided by the control unit 180, too.

30 **[0077]** Various modifications may be possible to the above-described

embodiments. For example, the dipole antenna 4a, the extension elements 24a and 26a, the PIN diodes 28a and 34a, the resistors 29a and 36a, the reactance elements 30a and 38a, the DC blocking capacitors 32a and 40a, the high frequency blocking coils 82a and 92a, and the voltage supply terminals 90a and 100a, only, may be used to provide a 8-shaped directivity pattern antenna, in which either of the extension elements 24a and 28a is connected to the dipole antenna 4a to thereby vary the directivity in the UHF band, while making the antenna receivable of radio waves in the VHF band coming from a given direction, only. In another modification, only the first antenna 2a may be used. In still another modification, by arranging the circuitry to apply a DC voltage between the dipole antenna 4a and the extension elements, the dipole antenna elements 8a and 10a need not be formed of two conductors. In such case, each dipole antenna element 8a or 10a may be formed of one conductor.

[0078] In the multiple frequency band antenna according to either of the first and second embodiments, one extension element, e.g. the extension element 24a, is disposed outward of the outer end of each dipole antenna element, e.g. the dipole antenna element 8a. Instead, an additional extension element may be disposed outward of each extension element, with a switch device disposed between each extension element and the additional extension element, in order to receive radio waves in a third frequency band which is lower than the second frequency band. In still other modification, the directivity of the antenna can be tilted in two different ways, one by connecting one extension element, e.g. the extension element 24a, to the associated dipole antenna element, e.g. the dipole antenna element 8a, and the other by connecting the extension element 24a and the additional extension element to the dipole antenna element 8a.

[0079] The directivity of the multiple frequency band antenna according to the first and second embodiments is varied by operating the 16-direction switch 176. According to a third embodiment of the invention, the directivity is varied in response to a command given from a receiving apparatus with which the

multiple frequency band antenna is used in a signal receiving system shown, for example, in FIGURE 12.

[0080] As shown in FIGURE 13, a variable directivity antenna system 500 has substantially the same configuration as the multiple frequency band antenna according to the second embodiment. Accordingly, components and functions equivalent to those of the antenna according to the second embodiment are given the same reference numerals and suffixes, and their detailed description is not given. It should be noted, however, that the antenna system 500 differs from the one according to the second embodiment in that variable filter means, e.g. variable filters 502a and 502b, are connected in the stage succeeding the variable phase shifters 106a and 106b, respectively. The variable filters 502a and 502b are bandpass filters with a variable passband. The passband of the filters 502a and 502b is varied in response to passband varying signals supplied thereto from passband varying control means, e.g. a control unit 180a. The passband of the filters 502a and 502b is varied in such a manner that the frequency of a radio wave to be received by the antenna system 500 can be within the passband. When, for example, radio waves in the UHF band are to be received, the passband of the filters 502a and 502b is changed so as to pass such waves, and if radio waves to be received are in the VHF band, the passband is changed to pass radio waves in the VHF band. Alternatively, high-pass or low-pass filters with variable cutoff frequency may be used in place of the bandpass filters 502a and 502b. In such a case, the cutoff frequencies of the filters are controlled such that the frequencies of radio waves to be received can be located within the passbands of the filters.

[0081] As shown in FIGURE 12, an input terminal 500a of the antenna system 500 receives a satellite broadcast intermediate frequency (IF) signal. The satellite broadcast IF signal is produced by frequency converting a signal received at a satellite broadcast signal receiving antenna, e.g. a satellite broadcast signal receiving parabolic antenna 506, in a converter 508 associated

with the parabolic antenna 506. The satellite broadcast IF signal is mixed in a mixer 509, with the output of the combiner 138 after it is amplified in an amplifier 507. The output of the combiner 138 is a UHF or VHF band television broadcast signal received by the antenna system 500. The mixture
5 signal is outputted at an output terminal 500b of the antenna system 500. The mixture signal at the output terminal 500b is coupled through a transmission line 510, and through a DC blocking capacitor 512 and a mixer 514, which are included in an antenna control commander 534, to a splitter 516, where it is separated into the satellite broadcast IF signal and the VHF or UHF television
10 broadcast signal. The satellite broadcast IF signal is then applied to a satellite broadcast IF signal input terminal 518a of a receiving apparatus 518, and the VHF or UHF television broadcast signal is applied to a UHF/VHF television broadcast signal input terminal 518b of the receiving apparatus 518.

[0082] The satellite broadcast IF signal at the satellite broadcast IF signal
15 input terminal 518a is applied to a satellite receiver 520, where it is demodulated into a signal which is applied to a television receiver (not shown). The VHF or UHF television broadcast signal applied to the UHF/VHF television broadcast signal input terminal 518b is converted to an intermediate frequency (IF) signal in a tuner 521 and applied to a demodulator 522. Regardless
20 whether it is an analog broadcast signal or a digital broadcast signal, the VHF or UHF television broadcast signal is demodulated in the demodulator 522, and the demodulated signal is coupled to the television receiver.

[0083] The IF signal from the tuner 521 is also applied to signal reception
25 condition detecting units, e.g. a C/N ratio detector 524, a bit error rate detector 526 and a level detector 528. The C/N ratio detector 524 detects the C/N ratio of the VHF or UHF television broadcast signal, and develops a C/N ratio representative signal, which is applied to receiving apparatus control means, e.g. a CPU 530. The bit error detector 526 detects, when the VHF or UHF television broadcast signal is a digital broadcast signal, the bit error of the
30 digital broadcast signal, and develops a bit error rate representative signal,

which is applied to the CPU 530. The level detector 528 detects the level of the VHF or UHF television broadcast signal and develops a level representative signal, which is applied to the CPU 530.

[0084] The CPU 530 is provided with a memory 532. When an external
5 command is given to the CPU 530 to receive a VHF or UHF channel, the CPU
530 reads antenna control data for that channel from the memory 532 and
applies the readout data to the antenna control commander 534. The memory
532 contains antenna control data for conditioning the antenna system 500 to
receive a desired radio wave (e.g. a television broadcast channel to be
10 received). For that purpose, the antenna control data indicates whether the
UHF band or VHF band is selected, in what direction the directivity is to be
directed, what passband the variable filters have to have, and what phasing the
variable phase shifters have to provide. The antenna control data is stored in
the memory 532, being related to channel data indicating television broadcast
15 channels to be received.

[0085] When the CPU 530 reads out of the memory 532, a channel data
piece for receiving a television broadcast channel, the associated antenna
control data is applied to the antenna control commander 534, which is provided
as a separate unit from the receiving apparatus 518. The antenna control
20 data is converted, in the antenna control commander 534, into a PSK
(Phase-Shift-Keying) signal, an FSK (Frequency-Shift-Keying) signal, or an ASK
(Amplitude-Shift-Keying) signal.

[0086] For conversion to an ASK signal, the antenna control commander
534 is provided with a carrier signal generator 534a, which generates a carrier
25 signal at a frequency, e.g. 10.7 MHz, different from that of the signal received at
and supplied from the antenna system 500. The carrier signal is supplied to
an ASK modulator 534b, which receives also the antenna control data supplied
from the memory 532 via a buffer 534c. The carrier signal is ASK modulated
with the antenna control data, and the resulting ASK signal is outputted from the
30 ASK modulator 534b. The ASK signal is caused to pass through a bandpass

filter 534d which removes undesired signal components before outputting the filtered ASK signal. For conversion to PSK or FSK signal, a modulator for PSK or FSK modulating the carrier signal with the antenna control data is substituted for the modulator 534b.

5 **[0087]** The ASK signal is supplied through the transmission line 510 to the UHF/VHF television broadcast signal output terminal 500b (FIGURE 13) of the antenna system 500, from which it is applied through the mixer 509 to the control unit 180a, where it is demodulated into the antenna control data, which is used to control the antenna system 500 in such a manner that it can exhibit a
10 directivity to receive the desired television channel.

[0088] The tuner 521, then, develops an IF signal, and the C/N ratio detector 524, the bit error rate detector 526 and the level detector 528 operate to detect the C/N ratio, the bit error rate and the level of the IF signal, and the respective representative signals are applied to the CPU 530.

15 **[0089]** If the channel currently being received is a digital broadcast signal, and when any selected one of the C/N ratio, the bit error rate and the level of the received signal as outputted from the tuner 521, which selected one may be the C/N ratio, is below a predetermined reference value, or, in other words, when the signal receiving condition becomes unacceptable, the CPU 530
20 operates to vary the directivity of the antenna system 500 to the new one which provides the C/N ratio above the reference value, and substitute the antenna control data for the new directivity for the antenna control data used to receive that channel at the unacceptable C/N ratio. The new antenna control data is stored in the memory 532 and is used to receive that channel after that.
25 When the bit error rate or the level is selected, a similar antenna control data renewal operation takes place.

[0090] If the channel being currently received is an analog broadcast channel, and when a selected one of the C/N ratio and the level of the received signal becomes below a predetermined reference value, the CPU 530 operates
30 to adjust the directivity of the antenna system 500 and renew the antenna

control data in a manner similar to the one described above with respect to the reception of a digital broadcast channel.

[0091] A DC voltage of, e.g. 12 V, is applied to the transmission line 510 from a DC power supply unit 536 in the signal receiving apparatus 518 through
5 a high frequency blocking coil 538 in the antenna control commander 534, from which it is applied to the UHF/VHF television broadcast signal output terminal 500b of the antenna system 500. This DC voltage is then supplied through the mixer 509 to a voltage supply 540 for application to the control unit 180a and other units.

10 **[0092]** In the third embodiment, the antenna control commander 534 is described to be external to the signal receiving apparatus 518, but it may be provided in the signal receiving apparatus 518.